ALTERRA
GREEN WORLD RESEARCH

perpest

Using the expert model PERPEST to translate measured and predicted pesticide exposure data into ecological risks

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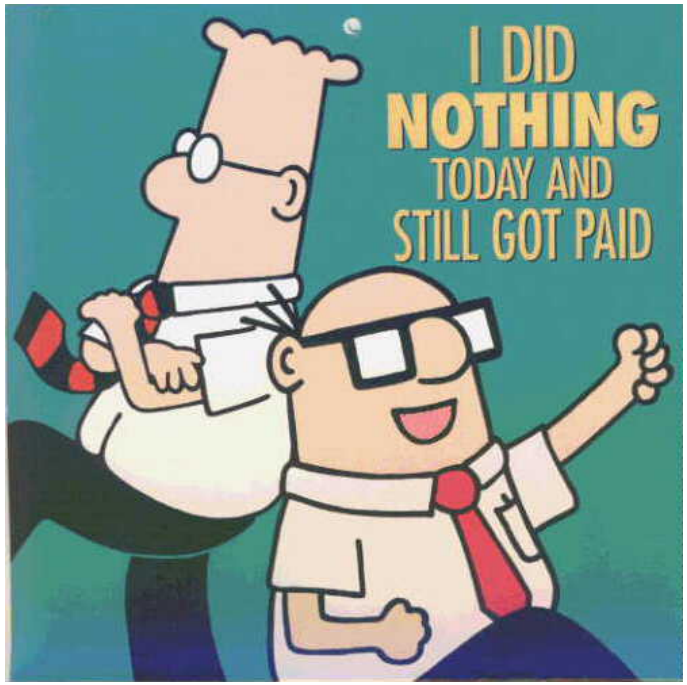
Why this presentation?

- To predict the future



- Dilbert's philosophy:
  Many methods to predict the future, but:

- Horoscopes, tea leaves, tarot cards, crystal balls → nutty methods
- Putting well-researched facts into sophisticated computer models → a complete waste of time

Why this presentation?

- **Dilbert's method:**

- **Use these far more efficient methods:**

1. My awesome powers of **logic**
2. My crystal-clear **observations**
3. My almost frightening **intuition**
4. My total **lack of guilt**

Case-Based Reasoning

- Reasoning by remembering
- Approach to problem solving and learning
- Works the same as people use cases to solve problems
- A methodology
  - to model human reasoning and thinking
  - for building intelligent computer systems

Case-Based Reasoning

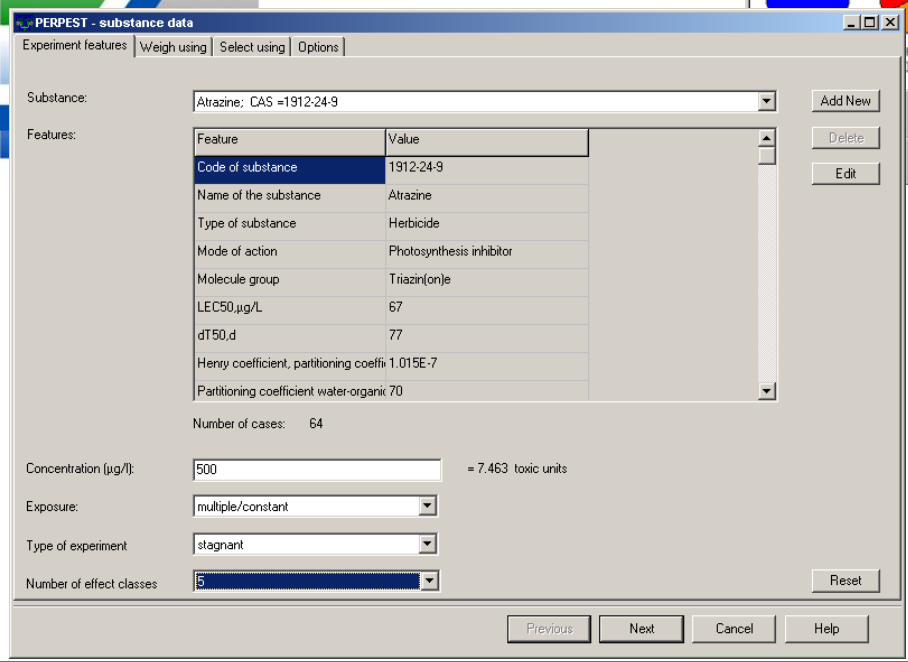
- Store previous experience (cases) in memory
- To solve new problems:
  - retrieve similar experience about similar situations from the memory
  - Reuse and adapt the experience in the context of the new situation
- Store new experience in memory (learning)

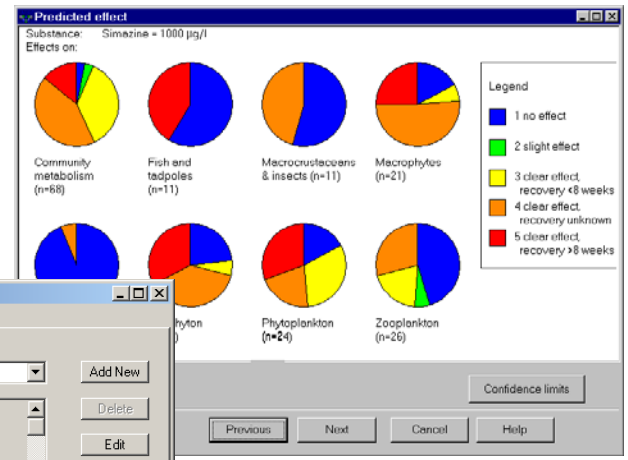
Case-Based Reasoning: PERPEST

PERPEST

a model to Predict the Ecological Risks of PESTicides

perpest





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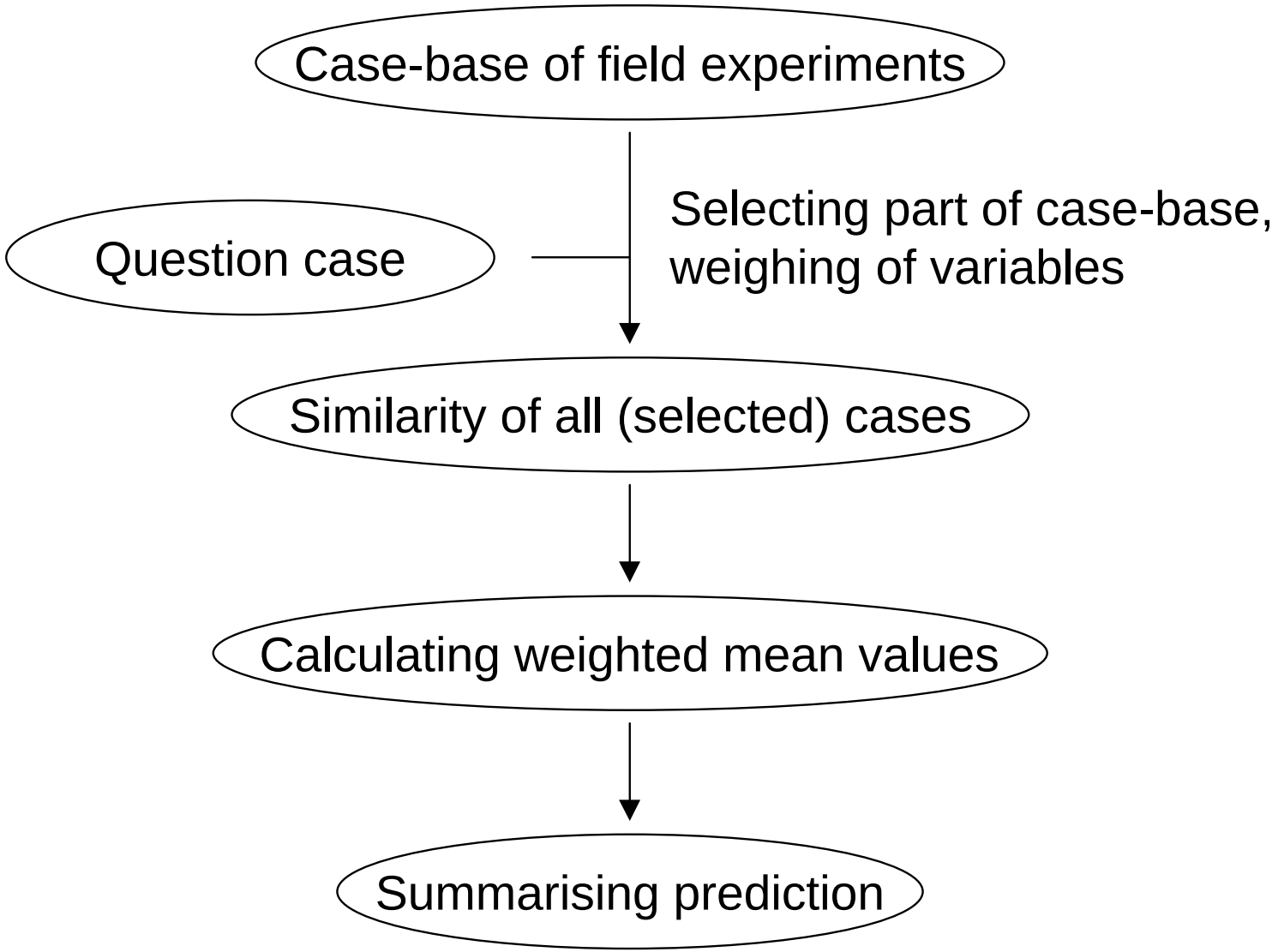
Case-Based Reasoning: PERPEST

- **Aim:** Predict effects of pesticides on freshwater ecosystems

- **Case-Base:** Results from microcosm and mesocosm experiments

Case-Based Reasoning: PERPEST



Case-Based Reasoning: PERPEST

Case base:

- **Field Experiments** evaluating effects of insecticides and herbicides using microcosms or mesocosms
- Passed several **quality criteria** (e.g. description of set-up is adequate, endpoints are sensitive)
- **90 experiments** evaluated (1980-2002) → **421 records** (substance * concentration)

  208 herbicide records, 213 insecticide records
- Effects evaluated on **8 groups of endpoints**

Case-Based Reasoning: PERPEST

- **Case-Base: Results from microcosm and mesocosm experiments**

CASE 1	**Problem**
	Problem: effect of Atrazine
	Concentration: 500 µg/L
	Reference: DeNoyelles et al., 82, 89, 94
	Exposure: multiple/constant
	Type of ecosystem: stagnant/recirculating
	Solution (effects observed)
	Grouped endpoint — Effect class
	Community metabolism — 3
	Phytoplankton — 5
	Periphyton — 0
	Macrophytes — 5
	Zooplankton — 4
	Macrocrustaceans & Insects — 4
	Other macro-invertebrates — 1
	Vertebrates — 5

Case-Based Reasoning: PERPEST

- **Effect classes**:

0. Endpoint not evaluated in the study.
1. No effects demonstrated
2. Slight effects.
3. Clear short-term effects, lasting < 8 weeks
4. Clear effects, recovery not studied
5. Clear long-term effects, lasting > 8 weeks

- Resulting database: 421 * 8 = 3368 entries (1424 non-zeros)

Case-Based Reasoning: PERPEST

Grouped endpoints:

Herbicides

- Community metabolism
- Phytoplankton
- Periphyton
- Macrophytes
- Zooplankton
- Macrocrustaceans & Insects
- Other macro-invertebrates
- Vertebrates

Insecticides

- Community metabolism
- Algae and macrophytes
- Microcrustacea
- Rotifers
- Macrocrustacea
- Insects
- Other macro-invertebrates
- Vertebrates

Case-Based Reasoning: PERPEST

Data selection/weighting database

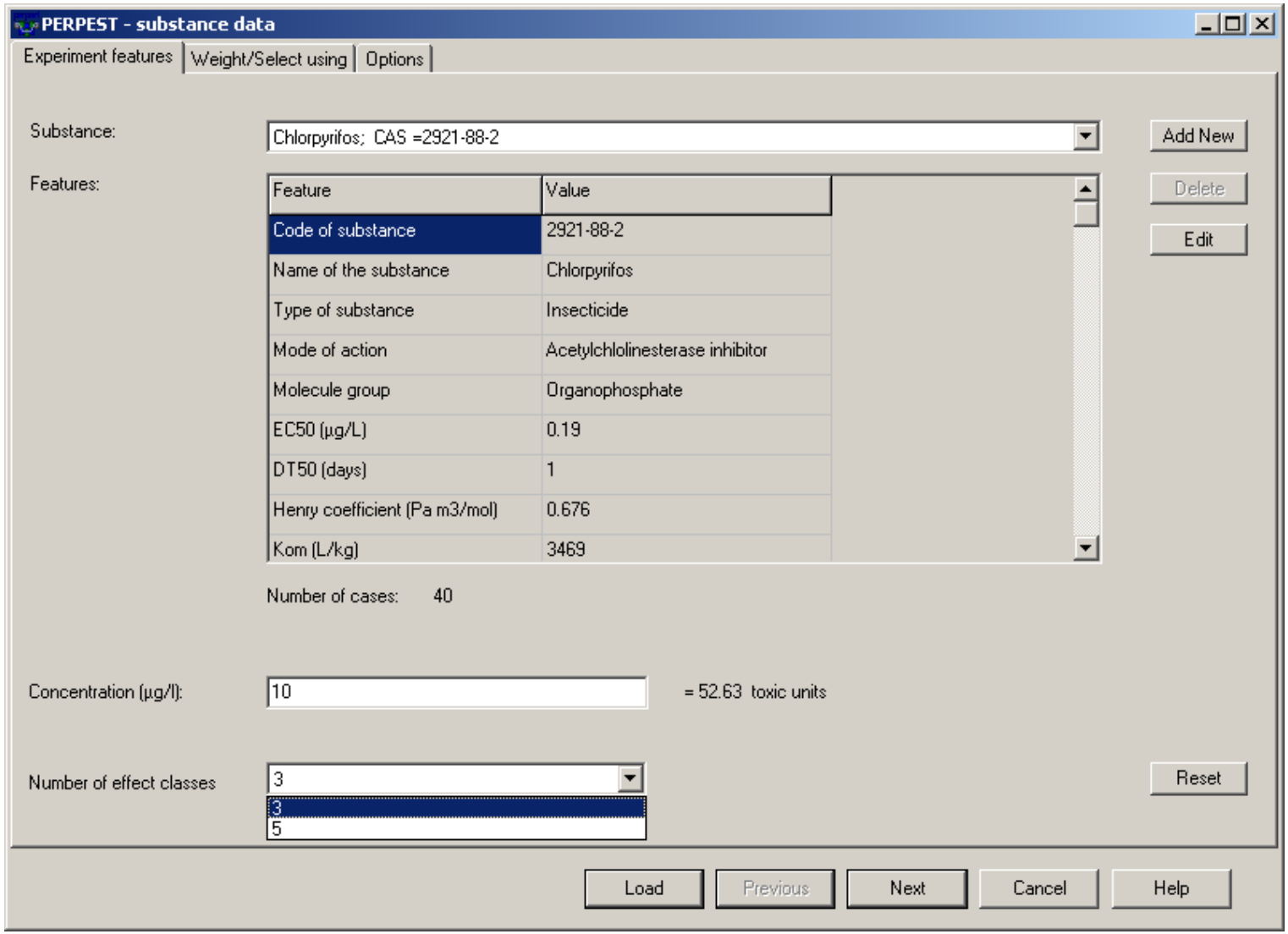
For every chemical or experiment:

- **Concentration of every case is standardised on the EC50 of the most standard test species (concentration/EC50) to make concentrations between chemicals comparable**

- **Type exp.:** acute/chronic, stagnant/flow-through
  Fate: DT50, Henry coefficient, Kom
  Molec. type: Insecticide/herbicide, Molecule group, Toxicological mode of action

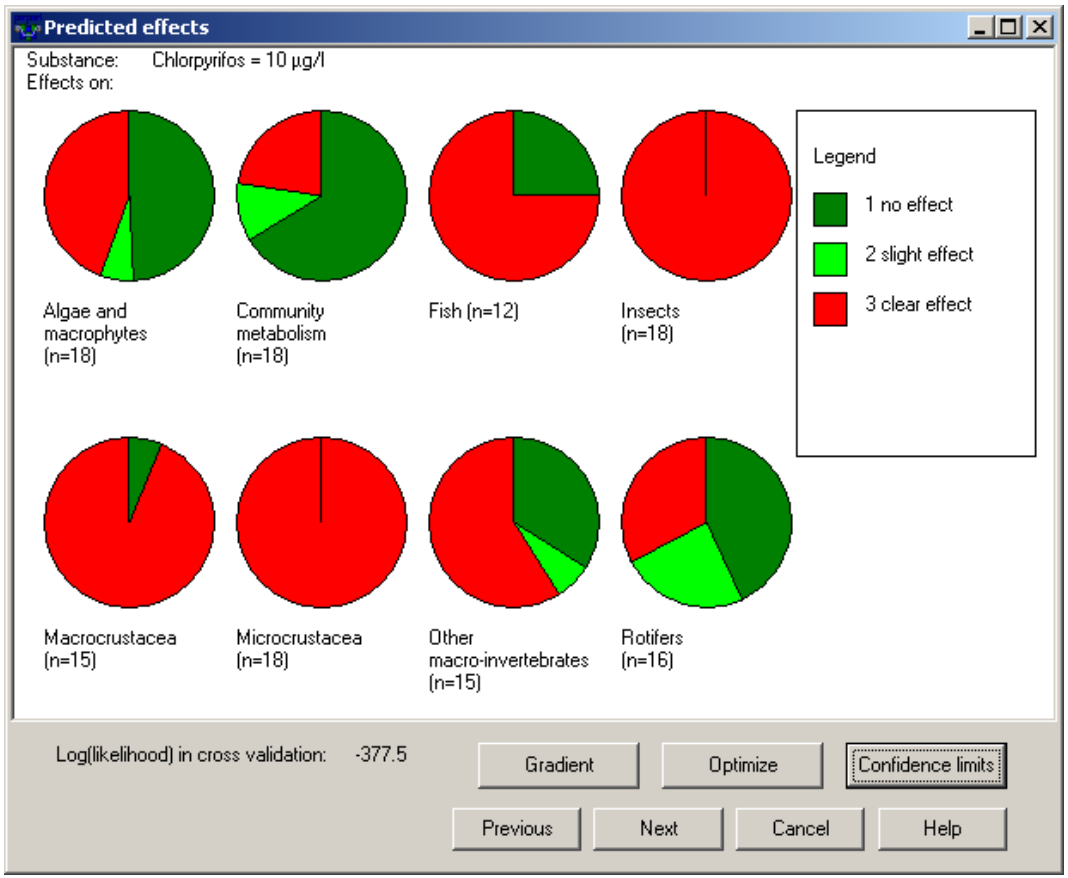
Case-Based Reasoning: PERPEST

- **Input**



Case-Based Reasoning: PERPEST

- **Effects of chlorpyrifos (10 µg/L), weight parameters optimised**

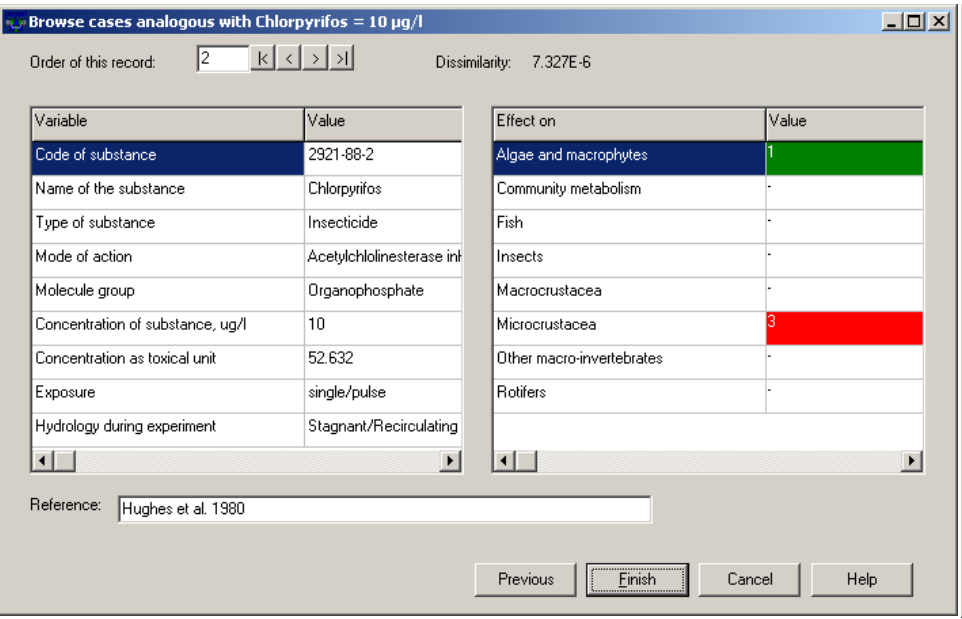


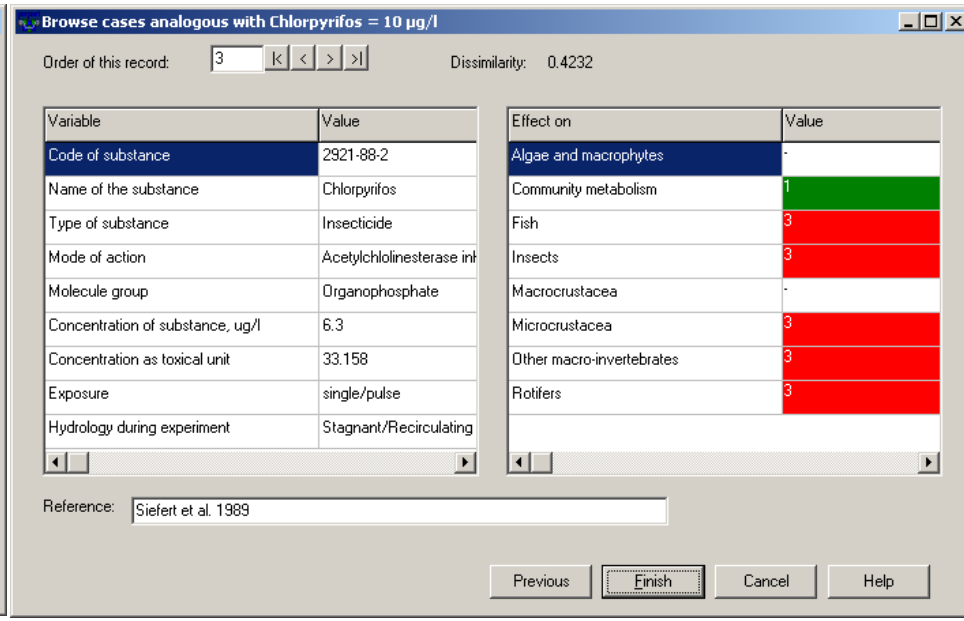
C.L. using bootstrapping:

Variable	Prediction	5% CL	95% CL	N
(Is) Insects = 1	0.00	0.00	0.00	18
(Is) Insects = 2	0.00	0.00	0.00	18
(Is) Insects = 3	1.00	1.00	1.00	18
(Is) Macrocrustacea = 1	0.06	0.00	0.21	15
(Is) Macrocrustacea = 2	0.00	0.00	0.00	15
(Is) Macrocrustacea = 3	0.94	0.79	1.00	15
(Is) Rotifers = 1	0.43	0.21	0.68	16
(Is) Rotifers = 2	0.24	0.06	0.46	16
(Is) Rotifers = 3	0.33	0.10	0.57	16

Case-Based Reasoning: PERPEST

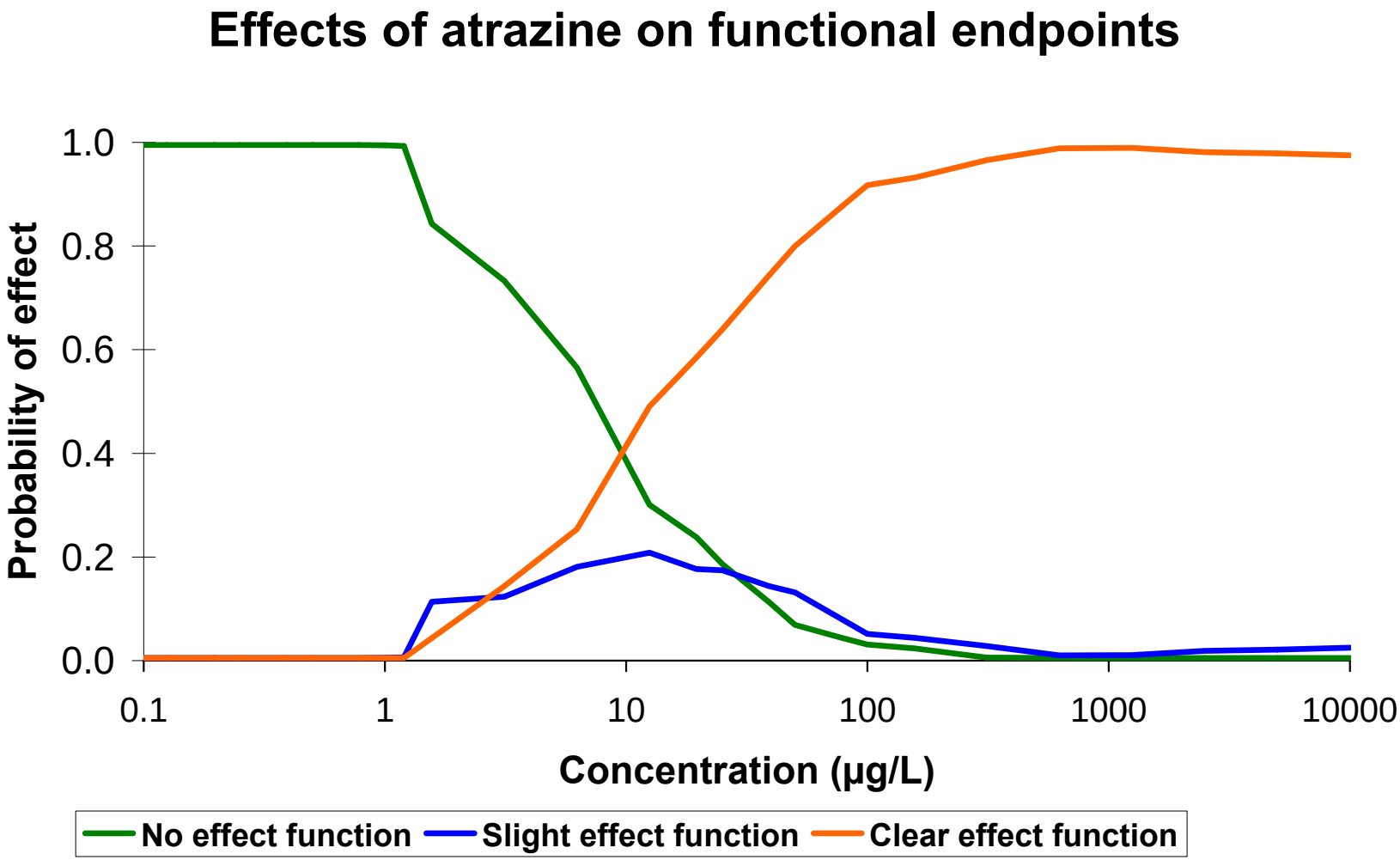
- Most **similar** cases





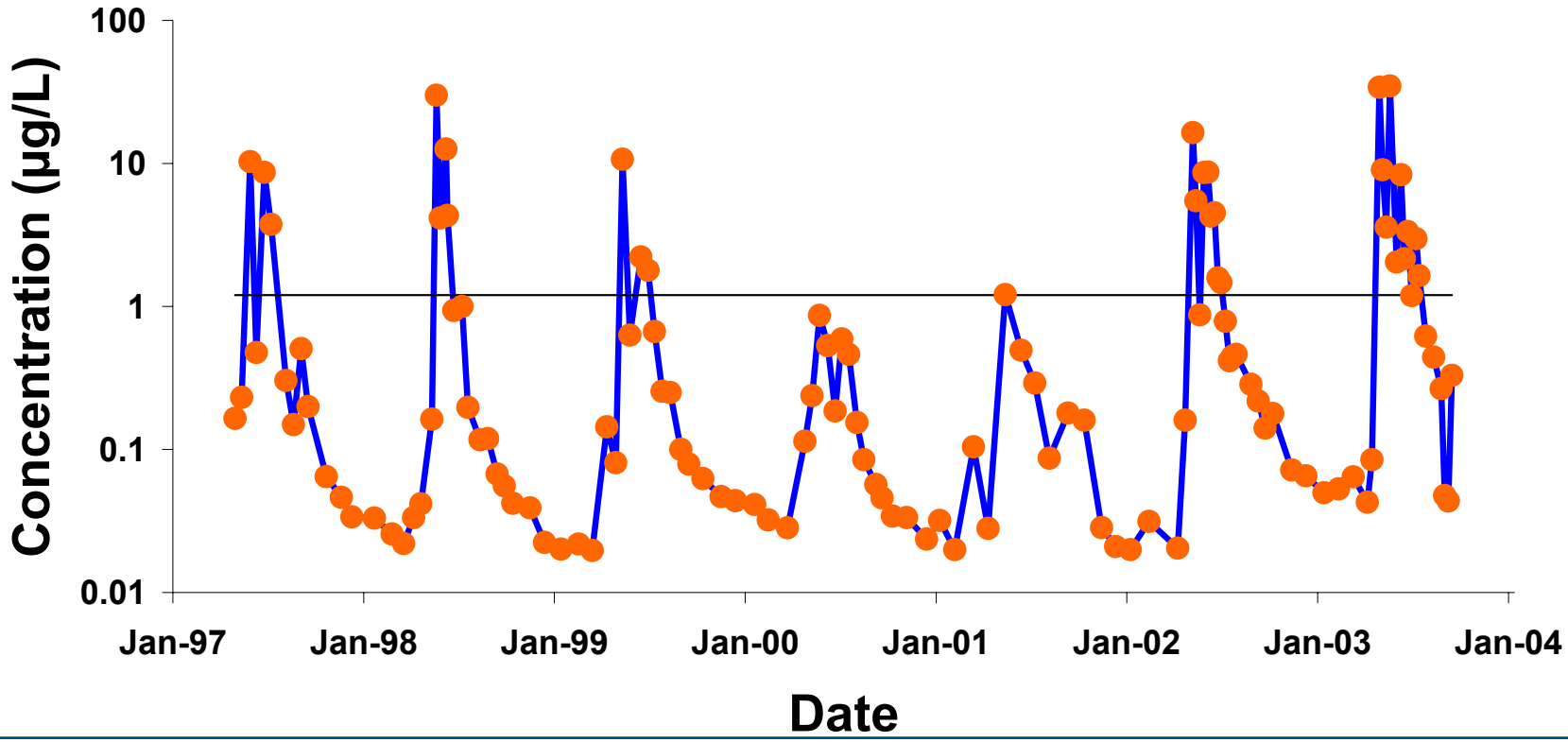
Case-Based Reasoning: PERPEST

- **Predict effects over a concentration range**



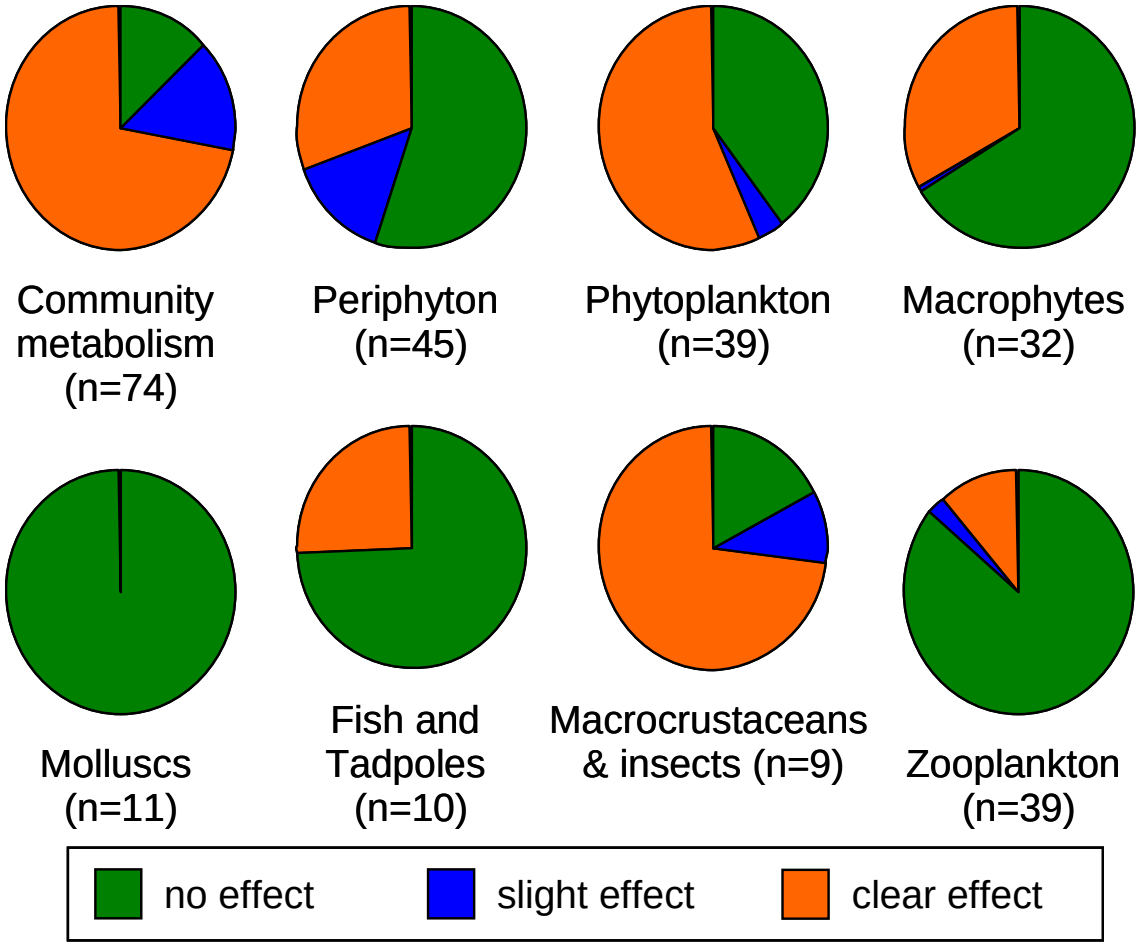
PERPEST: combining with measured data

- Maple Creek (Nebraska)
- 30-04-97 to 16-09-03: 124 values
- Max = 34.8 µg/L; geomean = 0.27 µg/L



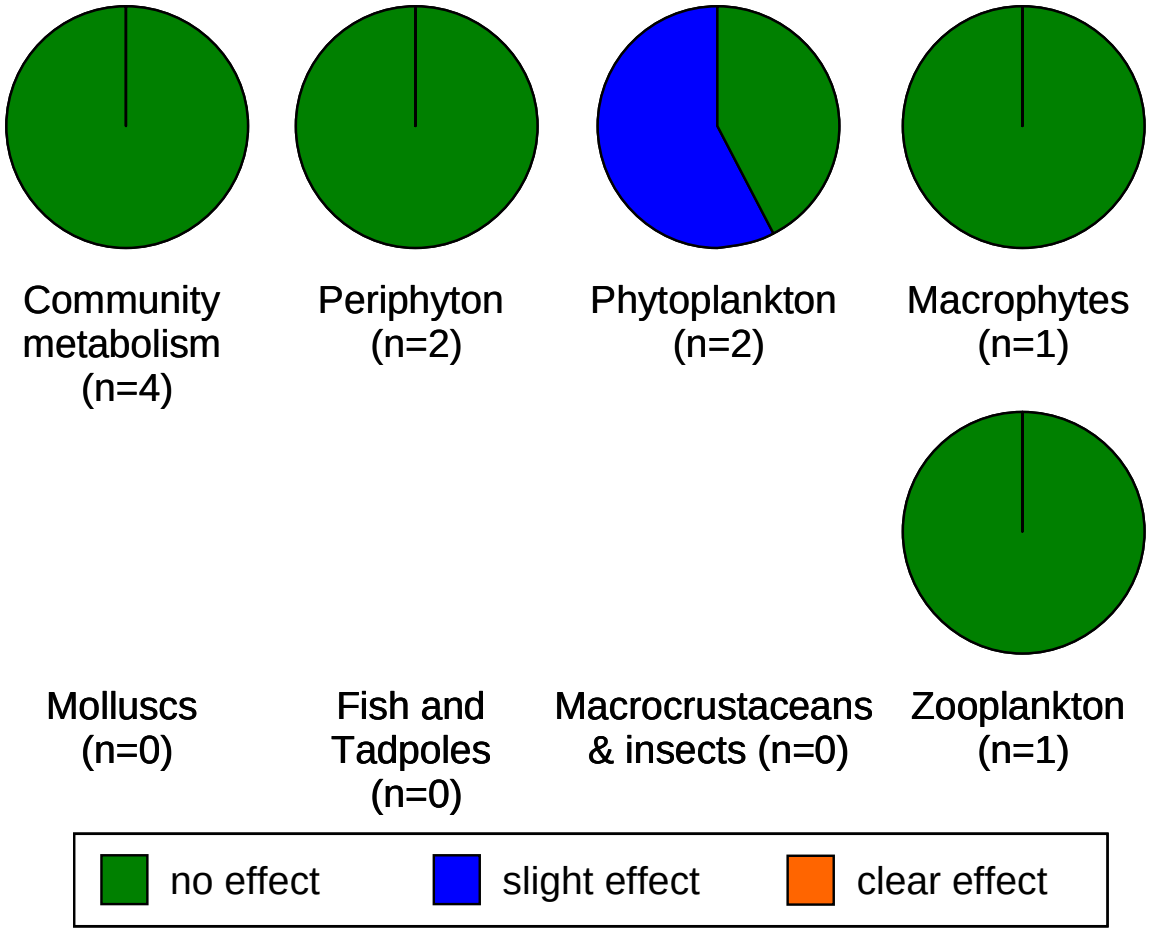
PERPEST: combining with measured data

- **Effects of maximum concentration: = 34.8 µg/L**



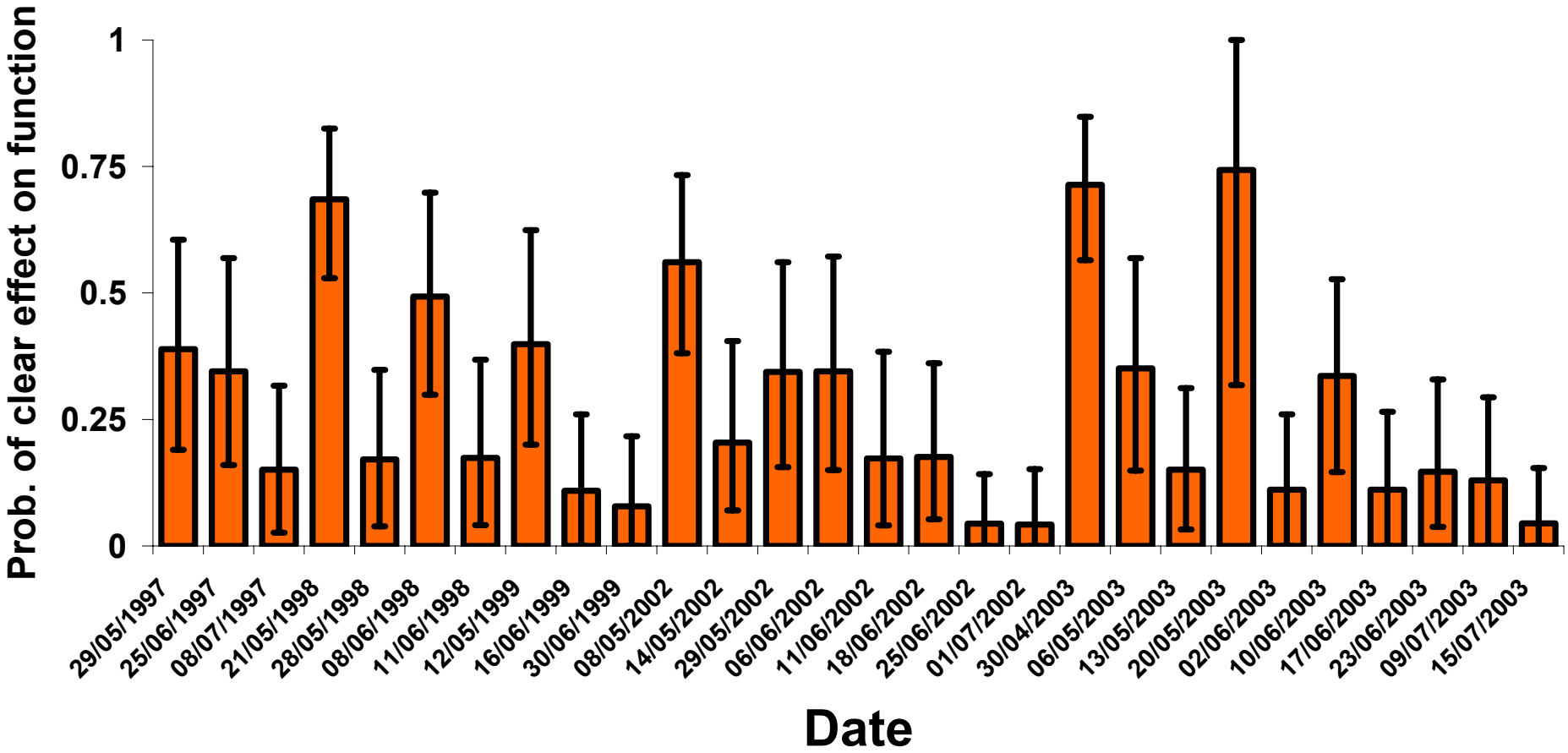
PERPEST: combining with measured data

- **Effects of medium concentration: = 0.27 µg/L**



PERPEST: combining with measured data

- **Probability** of measured concentrations leading to clear effects on **functional endpoints**



PERPEST: combining with measured data

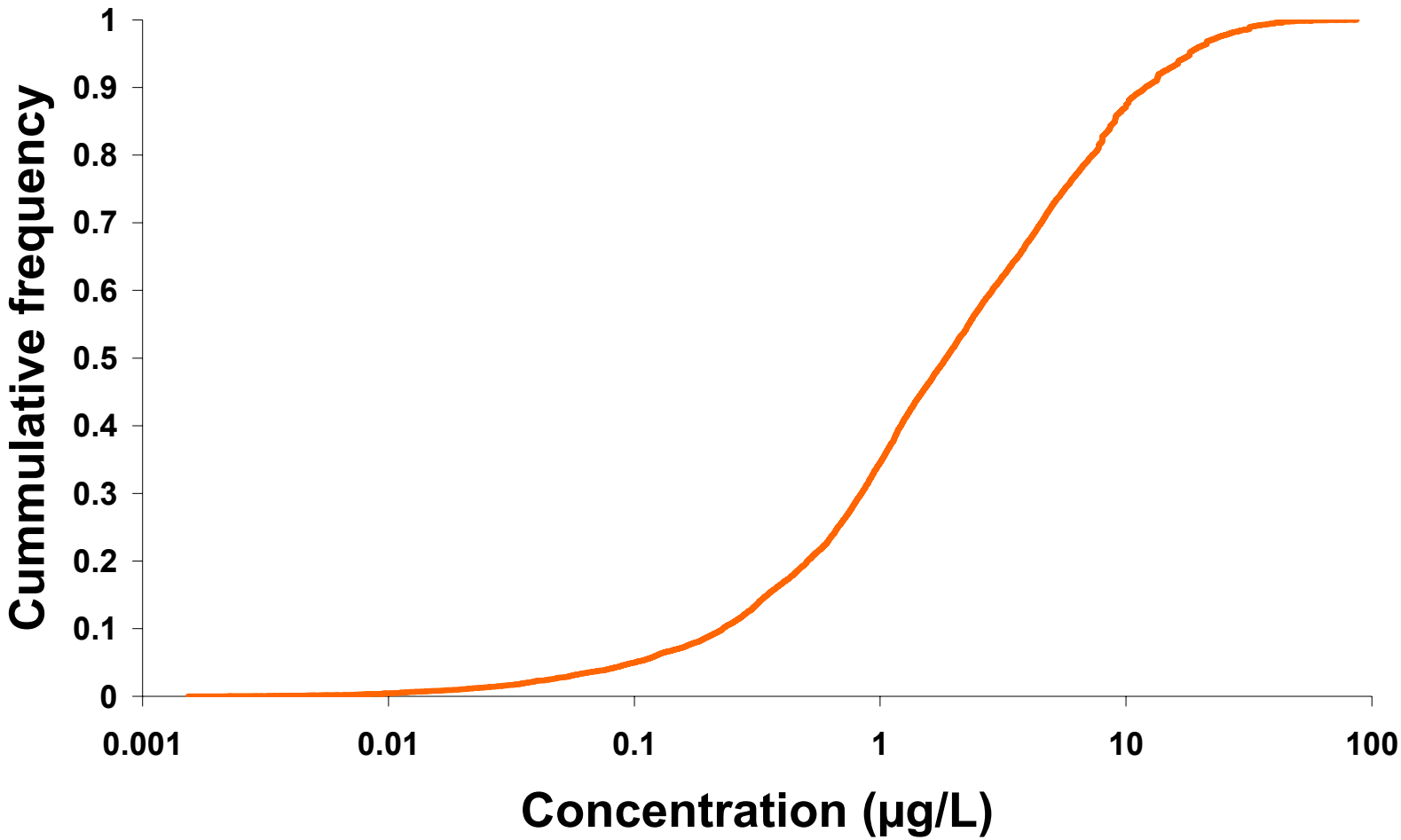
- Functional: in 43% of the cases: chance > 25% on a clear effect
- Functional: in 14% of the cases: chance > 50% on a clear effect
- Structural: 43 and 11%, respectively

- (1) If the structure and functioning of the model-ecosystems as well as the (2) exposure regime, used in the experiments incorporated in PERPEST are representative for Maple Creek:

➢ it is very likely that atrazine contamination affected the aquatic community during the last 7 years, in particular in the year 2003.

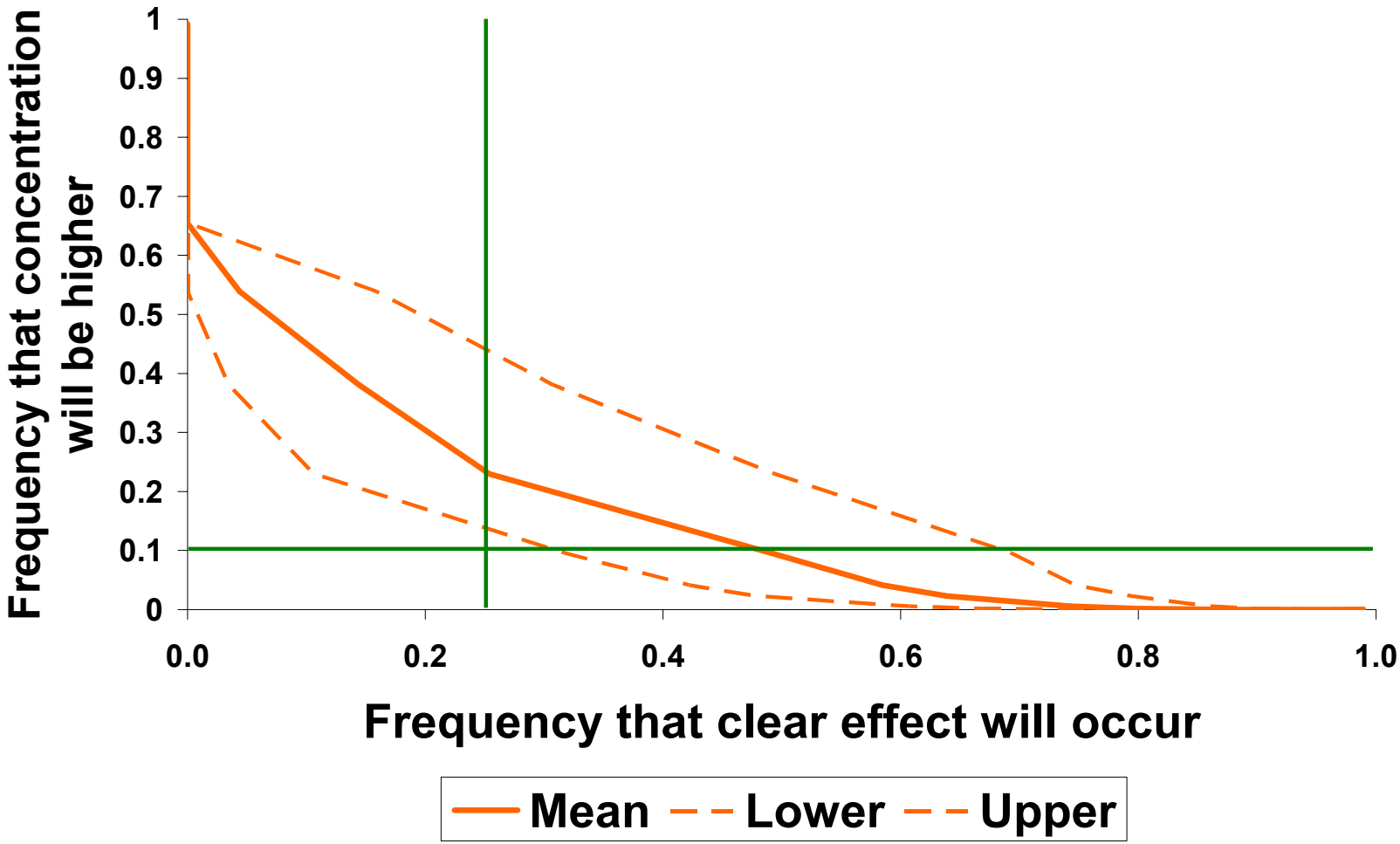
PERPEST: combining with modelled data

- **Cumulative Distribution Function modelled conc.:**



PERPEST: combining with modelled data

- **Joint Probability Curve:** Clear effects on function



PERPEST: combining with modelled data

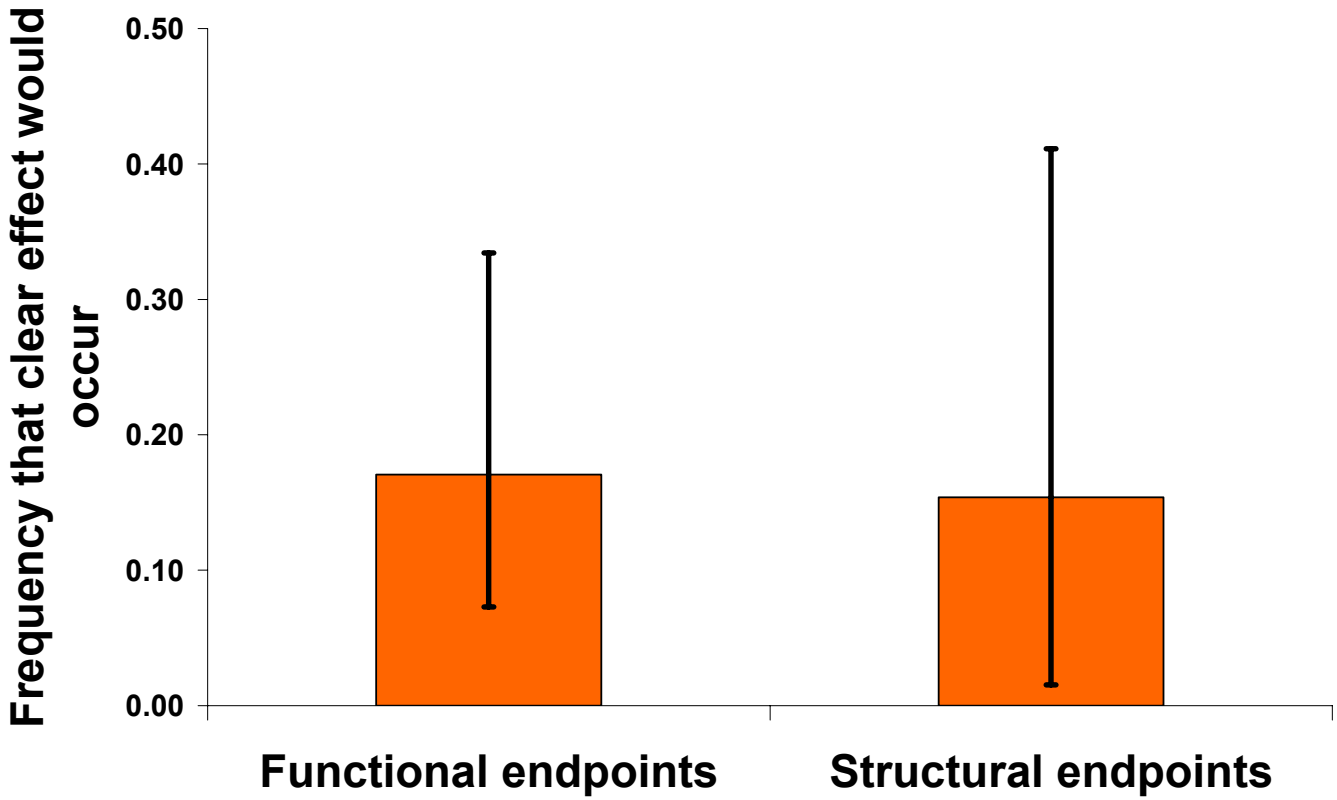
- The 90% exposure concentration (= 0.1 frequency on y-axis) is estimated to result in clear effects on community metabolism with a frequency of 49% (95% confidence interval 31 – 69%),
- A 25% frequency of clear effects on community metabolism occurs for 77% (95% confidence interval 56-86%) of the exposure distribution,

- assuming that

1. the exposure model is correct and
2. that mesocosm studies directly represent effects in the field.

PERPEST: combining with modelled data

- **Both axes of JPC are proportions of application events, so can be combined to estimate the overall frequency that clear effects would result → area under the curves**



PERPEST: discussion

- A key advantage of PERPEST over single species tests and safety factors is that it removes the uncertainty of extrapolating to the ecosystem level

- PERPEST makes some assumptions, however:

1. The cases are representative for the question case with respect to ecosystem structure and functioning and exposure regime
2. The calculations of dissimilarity and transformation, standardisation and weighing of variables are adequate for making predictions
3. The number of cases is sufficient for making a prediction
4. ????? Please add !!!!!

PERPEST: discussion

- PERPEST might underestimate effects for measured concentrations → water samples not been taken at highest concentrations
- Shortcoming of chemical monitoring in general, not of PERPEST
- PERPEST can evaluate monitoring activities in the light of the Water Framework Directive
- Overall risk of pesticides with similar mode of action can be assessed by adding chemicals up as toxic units
- Dissimilar mode of actions can be combined using response addition to an overall risk of all pesticides measured

PERPEST: discussion

- Obvious drawbacks:

1. often only very few really comparable cases are available; and,
2. specific cases are often too easily generalised

- Seek the best of both worlds by:

1. using CBR as a mimic of the experts' approach and
2. fine-tuning the results with simple ecological models

- Empirical models + ecological models = model-based adaptation

PERPEST: overview

- **Semi-field database** is published (Brock et al., 2000a,b) and updated last year (2003)
- **Scientific paper** published in ET&C (2002), **Manual published** as Alterra report (2003), Scientific paper for **this conference** (2004)
- **Model, paper and manual are available** via **www.perpest.alterra.nl**
- Data on **fungicides** will be added next year

Why this presentation?

Dilbert's method:

1. **My awesome powers of logic**
- **Events in the past are predictive for the future**
2. **My crystal-clear observations**
- **I did a good job reviewing all these microcosm and mesocosm experiments**
3. **My almost frightening intuition**
- **Other traits than concentrations alone also matter (like type exp., fate and molecule type)**
4. **My total lack of guilt**
- **Detail doesn't matter (i.e. ignore assumptions)**